ON

WARDIAN CASES FOR PLANTS,

AND

THEIR APPLICATIONS.

ON

WARDIAN CASES FOR PLANTS,

AND

THEIR APPLICATIONS.

BY

STEPHEN H. WARD, M.D., Lond.

LONDON:

JOHN VAN VOORST, 1, PATERNOSTER ROW,

MDCCCLIV.

The following is the substance of a Lecture which was delivered at the Royal Institution on Friday, March 17th, 1854, and is published at the request of several friends. For general information on the subject of which it treats, and for directions and designs for the construction of cases, the reader is referred to the work entitled, "On the Growth of Plants in Closely-glazed Cases," published by Mr. Van Voorst.

LONDON:
T. E. Metcalf, Printer, 63, Snow Hill.

ON

WARDIAN CASES FOR PLANTS,

AND

THEIR APPLICATIONS.

Mr. President, — The subject on which I have pledged myself to lecture this evening, is "The Growth of Plants in closely glazed cases;" and I may state at once, that I stand here as an expositor of a plan discovered, and of views entertained, by my father, who, I had hoped, might have been induced himself to address you. Sixteen years ago, Professor Faraday, having mastered the subject with the ready grasp of comprehension which eminently characterizes him, introduced it to the notice of a numerous audience on one of these Friday evenings; illustrated it in his usual felicitous manner; and enlarged upon probable future applications. This evening I gladly, though not a little nervously, considering the circumstance just noticed, and the audience I am now addressing, avail myself of the opportunity offered, to demonstrate the success that has attended the plan up to the present time, and to vindicate Mr. Ward's title to such applications thereof as could scarcely fail to have suggested themselves to a philosophic mind.

It is advisable, I think, to act upon the presumed unacquaintance with the matter of some of my audience, and accordingly, in the first place, to glance back

at the incident which led to Mr. Ward's discovery, and to dilate somewhat upon the principle and mode of construction of his cases for the growth of plants.

The love of nature, which seems to cling with almost instinctive tenacity around man's heart, has exhibited itself even under circumstances calculated to quench all his higher yearnings. From time immemorial, the denizen of the crowded city has endeavoured to compensate for the loss of the country by various "supplemental shifts," in the form of miniature gardens, set with mignionette, or filled with a formal array of plants of hardy constitution. Barely preserving any verdure by daily sponging and frequent application of the watering-pot, these sickly nurslings maintained a mere existence in the uncongenial atmosphere and soil, and too often prematurely drooped and withered, despite the almost parental care bestowed upon them.

Impelled by such instinctive love, and still further actuated by an ardent zeal for the science of botany, Mr. Ward had for years striven to realize the "*rus in urbe.*" Not content with the plebeian myrtle, geranium, and rhododendrum, he had extended his attentions to the more delicate members of the vegetable world. All the protection, care, and nursing that he could bestow upon his pets, were, however, ineffectual in enabling them to maintain the struggle with opposing influences. The soot and dust clogged up their tender lungs, and impeded their respiration; the cold, dry winds carried off the vapour from their leaves and the moisture from the mould in which they were planted, and caused them to shrink and wither; the deleterious gases entangled in the smoke-cloud poisoned them. The only resource left him was, on each occasion of a visit to the country, to bring back a fresh relay of plants, and thus maintain a fluctuating appearance of freshness and verdure. In the summer of 1829 he had placed the chrysalis of a sphinx in some mould in a glass bottle, covered with a lid, in order to obtain a perfect specimen of the in-

sect. After a time, a speck or two of vegetation appeared on the surface of the mould, and, to his surprise, turned out to be a fern and a grass. His interest was awakened: he placed the bottle in a favourable situation, and found that the plants continued to grow and maintain a healthy appearance. On questioning himself about the matter, the answers readily presented themselves; inasmuch as air, light, moisture, and other requirements of the plants, were contained within the bottle.

This parent closed-case soon gave birth to numerous others: the plan was tested, and its success demonstrated, under varying conditions as regards size, aspect, and different tribes of plants; and, after a few years, Mr. Ward had the satisfaction of feeling that, through his discovery, he had been the means of introducing Nature into the crowded city in all the attractiveness and purity, if not on the extended scale, in which she exhibits herself in the country. Thousands of times, as he remarks, the hint must have been given to horticulturists and philosophers,* in some incident analogous to that which set him to think and act; and he admits that a more philosophic mind might sooner have arrived at results which, to him, were of comparatively tedious growth; but, at times, Nature may be courted when she cannot be constrained, and love may prevail with her where science has failed.

Such, then, was the origin of these cases. What is their principle, and how are they constructed? There is no mystery about the matter. The principle is, the exclusion from the plants of deleterious influences and agents, the admission and retention of those that are necessary; and the principle is realized in a stoppered bottle, a garden-pot or a saucer covered with a bell-glass, or a trough surmounted by a glazed frame-work.

* Philosophers had been in the habit of experimenting upon the action of gases upon plants in glass bottles; horticulturists had long had their hand-glasses and closed frames, but the application in question had never struck them.

The unreflecting talk of these cases as being hermetically sealed, and enquire how the plants are kept alive without air; others again, speak of them as being air-tight. Closely glazed they are, but not hermetically sealed; not, strictly speaking, closed. Closed to adverse, open to genial and indispensable influences. Excluding soot, and dust, and noxious gases, guarding against sudden changes, preserving the nutritious vapour, admitting light, and, subtly, but certainly with every change of temperature, and in obedience to the great diffusion law, such renewal of the air as is necessary to the existence of the plants.

Nothing can be more simple than the construction of a Wardian case. An earthenware or metallic trough, with a nicely adapted bell-glass or glazed frame-work, is to be procured; and, supposing that ferns are to be grown in the case, the mode of arranging it is as follows. The trough is to be filled to the height of an inch or so with broken pieces of stone, potsherds, &c.: upon this, a mixture of peat and loam is to be placed; and then on the surface any picturesque arrangement of rock-work or artificial elevation. The ferns are then planted, the mould is thoroughly saturated with water, the glass covering is fitted on, and the case is placed in a situation where it may be sufficiently exposed to light, and, in the case of ferns, not to the full force of the sun's rays. In order to allow of the drainage of superfluous water, it is necessary either to have apertures perforated in the bottom of the case, or a depression in the least conspicuous corner, from which such superfluous water may be removed by means of a sponge or syringe.

Now, in a case so constructed, what takes place? Without at present considering physiologically the influence of light, heat, air, and water, upon plants, which time would not permit me to do, I may state that their natural conditions in reference to these several vital stimulants are fully realised. The closely-fitting glass shade, or glazed frame-work, admits freely the light which is indispensable, if not to the exist-

ence, at least to the vigorous and healthful growth of plants, since without it they are not duly nourished, and grow devoid of odour and colour, feeble, sickly, and unattractive in aspect. In the second place, the water with which the mould has been saturated, and without which neither seeds nor plants can develop and grow, is retained, or escapes only in inappreciable quantities. Exhaling from the leaves, and rising from the surface of the mould in the form of vapour, it becomes condensed in small beaded drops on the inner surface of the glass, which coalesce and form little streamlets which course down the side of the glass: the water is absorbed by the mould, taken up in part by the plants, and again rises, becomes condensed and falls, and so keeps up a ceaseless circulation; the quantity lost being so trifling, that plants may perform the longest voyages, or, as in the case of the first experiment bottle, may grow prosperously for the space of four years without receiving one drop of fresh water. Mr. Ward has one bottle, the plants in which have had no fresh supply of water for eighteen years. The outer surface of the case will be found, at any rate in any room in London, to be covered after a short time with soot and dust, thus indicating another beneficial influence exerted by the glass in excluding that, which, if the plants were exposed, would cover their leaves, and materially interfere with the due performance of their functions.

Heat is well known to be essential to the life of plants; and for the growth of many, under ordinary circumstances, a tolerably high temperature is necessary. Now, it is a curious and interesting fact, that in these cases the plants of temperate zones will bear a much higher, and those of the torrid zone, a much lower temperature than they could do if exposed to the external air, and may be sent in company on a voyage either across the Equator or to the Arctic regions How is this? Why, simply because the air confined in these cases is almost perfectly tranquil, and,

consequently, less readily affected by changes of temperature than one agitated by winds and currents of air, which affect plants as well as human beings by the rapidity with which they carry off the protective vapour which envelopes them. It is through this tranquillity of the air that flowers remain much longer in bloom than they would do if unprotected; and, even cut flowers, placed under a glass shade, may be preserved for a very considerable period, simply because they are not exposed to currents of air which, by carrying off the aqueous exhalations from their surface, would cause them soon to dry and wither. Some cut camellia-flowers, which were treated in this way, retained their freshness for nearly a month.

Lastly, with regard to the admission of air. These cases, as I before said, are not and cannot be, strictly speaking, closed or hermetically sealed. If they were, the first alteration in the relative density of the air within and without would result in the fracture of the glass. Change of air, it is true, is effected very subtly, almost insensibly, but still it must be going on with every change of temperature, and still more in obedience to the marvellous diffusion law, by which gases of different specific gravity become intimately blended; finding an exit through bladder and other membranes, rising against the attraction of gravitation, and in the teeth of obstacles greater than can be presented by a glazed covering, which is only in close application with, not amalgamated to, the case below.

Now, while the several natural conditions which I have noticed are fully realised, it will be obvious that in one of these cases we possess the means of so modifying such conditions as to suit the requirements of different kinds of plants. Thus, ferns generally thrive best in a peaty mould, well saturated with moisture, and in a situation where they receive a free supply of light, but are protected from the direct rays of the sun. In illustration of the perfection to which ferns may attain under this plan, I may notice the success

which, in the hands of different amateurs, has attended the growth of one of the most delicate and beautiful, the *Trichomanes speciosum*. Formerly, in consequence of the occasional dryness of the atmosphere, and the presence of adventitious matters even in the best-constructed conservatories, it was almost impossible to cultivate this plant. Now, in one of these cases, where it has a perfectly pure and highly humid atmosphere, it will grow as well in the dirtiest parts of the metropolis as in its native locality; and in the first experiment made with it under this plan it produced fronds one-fourth larger than native specimens either from Killarney or elsewhere. As small triumphs in the culture of this plant, I may notice a fine specimen reared by my brother in the heart of the city, and another by Mr. Callwell, of Dublin, which, remarkably slow as the plant is of growth, has produced in a few years 230 fronds, varying in length from 14 to 20½ inches.

For flowering plants a different soil is necessary; generally, less moisture, a larger volume of air, and more or less exposure to the sun's rays. But that, by attention to their peculiar requirements, they can be grown just as successfully in these cases as ferns, is proved by the fact, that in the most smoke-charged atmosphere in the East of London, various spring flowers, fairy roses, and so on, flowered year after year most luxuriantly, and remained in flower much longer than they do in our country gardens. So, also, with respect to cactuses, succulent, and other tribes of plants, perfect success may be insured by simple acquaintance with, and attention to, their several natural conditions. We obtain, in short, in the isolation afforded by the glass covering, a climate within a climate, a little world within a world, in which, while their wants are satisfied, the plants enjoy an immunity from external disturbing influences.

With regard to the cases themselves, they may, of course, be varied to an indefinite extent, both as to

dimension and design. For the suggestive diagrams I am indebted to E. W. Cooke, A. R. A., who has brought his artistic taste to bear in the construction of these cases, and, by diminishing the depth of the trough, and increasing the surface by picturesque central elevation, has produced a light and graceful effect. As regards size, these cases vary from that of the little bottle I hold in my hand, to that of the Crystal Palace, which will, I trust, prove a sufficiently closed case for the denizens of the tropics that are destined to inhabit it.

And, next, as to their application. The first, and one of the most important, is to the growth of plants in towns and cities. By their means, the citizen living in a smoke-charged atmosphere, and surrounded by walls and houses, is enabled at all times of the year to enjoy living reminders of the freshness and beauty of the country. Instead of looking out from the window of his breakfast-parlour or library upon dingy walls and tenements, he may ever refresh his eye with the prospect of ferns and flowers. He need not rest content with having a window-space occupied by one of these cases, but, if his means permit, may build out from one of his rooms a closed case of considerable magnitude, in which, by aid of moderate artificial heat during the colder period of the year, he may blend with the beauties of his own land some of the more striking productions of tropical regions, and add to the general effect by raised rock-work, or the model of some old ruin, with the addition, perhaps, of a fountain-basin for gold-fish, or other small aquatic animals in the centre. To point out the delight afforded to the eye, and the interest to the mind, by such a case, would be superfluous. In this country, where winter prevails for so many months, and perchance snow, or, at any rate, rain and fog are our constant visitors, a contrivance by which, in the enlivening and refreshing influence of the most attractive plants, we may for a while forget the drizzling rain, the biting wind, and the stifling fog.

must be regarded as an especial boon. In the miniature conservatory, even in the most cheerless season,

> "Unconscious of a less propitious clime,
> There blooms exotic beauty warm and snug,
> While the winds whistle, and the rains descend."

Various are the ways in which we may apply these cases to the decoration of our homes; and the time is not, I believe, far distant, when they will be had recourse to, to a much greater extent than they have yet been. Not only may they be used, as already indicated, as substitutes for window-blinds, but the entire space or spaces between the windows of a room, which, under the present system of domestic architecture are usually so dark that they are unavailable for pictures or any other purpose, might be converted into Wardian cases. Opportunity would thus be afforded for the exercise of taste, in constructing designs for the surface on which the plants were to grow; and while such cases afforded a source of constant attraction, they would render a room so furnished lighter, and consequently healthier and more cheerful.

The forms of Wardian cases I have just noticed are procurable only by those of tolerably ample means. Now the cultivation of plants has ever eminently been the poor man's luxury. He cannot embellish his room with choice specimens of the first masters in painting or sculpture, and he may be unable even to procure good engravings or casts from the antique; but he can go out into the fields and woods, and become possessor of forms of beauty, and adorn his humble dwelling with the productions of the greatest Master. To such a luxury, to the taste which the poor man often exhibits for the lovelier works of creation, these cases, less expensively constructed, may be made to minister; and they may serve yet a higher purpose. The plants flourishing in their little world, in places where formerly they must have perished, may perchance lead him to reflect upon man's controlling influence over the powers

of Nature, may teach him that obstacles and difficulties are to be wrestled with, not yielded to, and may awaken in him a higher sense of his own capacities and dignity.

Though not the only, yet certainly, the most grateful acknowledgements for his discovery, where thanks were the only return that could be made, have been those received by Mr. Ward from one or two artisans, of which the letter of Mr. Ivey, contained in his work, is an illustration. Some years back, some money was contributed by a philanthropic nobleman for the construction of some cases for the poor. These were committed to the care of some of the better class of poor, to whom they were not only a constant delight, but also a source of profit, in the rearing and subsequent sale of plants, and in the growth of herbs for salad. Cases adapted for this purpose may, in fact, be procured at a very trifling expense; and the plants that would flourish best in them, the primrose and anemone in spring, the wood-sorrel, the pimpernel, the common ivy, which may be trained over any part of the case, the less rare kinds of fern, and others, may be obtained for nothing in a long walk, or a very short railway ride out of London.

In noticing the next application of these cases, I cannot refrain from allusion to a subject in which, as a medical man, I have long felt deeply interested. I mean, the æsthetics of the sick-room, or the beautiful, whether in nature or in art, as an important moral agent in the treatment of disease. In many acute maladies, especially those in which the senses are morbidly excited, it is, doubtless, necessary to keep the room in perfect tranquillity and comparative darkness; but during the period of convalescence from most diseases, and in the treatment of those of a chronic nature, where the cure is tedious, or, where, as in consumption, a fatal result must sooner or later transpire, such precautions are both needless and prejudicial. Many of those whom I now address must remember that period in the course of a severe illness,

when the acute symptoms have been subdued or the fever has left them out of danger, but as yet prostrate in power; how, as the mind began again to rally and the eye to look around, every object in the sick-chamber became a living reality. The very pattern on the bed-curtains, the colour and tone of the room, impressed their influence upon the mind. How if, instead of chintz or other grotesque designs which became phantasms while we looked upon them, the eye had then been arrested by some beautiful work of art, or by some lovely ferns or flowers in an elegant case; can we doubt that the sight of such would at once have given a cheerful impulse towards recovery? And in the tedious period of convalescence, might not morbid feelings have been dissipated, and the thoughts diverted from still lingering symptoms, by the cheering presence of things of beauty? The very light which would be requisite for the plants, in most instances would act as a tonic to the patient by directly healthfully stimulating the nervous system, and, through it, restoring the functions of different organs. The principle that

"Whatever cheerful and serene
Supports the mind, supports the body, too,"

has, I admit, been recognised as of high importance in the sick-room; but while most relatives act upon it in a well-meaning, but few do so in an intelligent spirit. These cases, in the application upon which I am now dwelling, present an advantage over plants in pots, &c., because while they maintain greater freshness and luxuriance, they confine the exhalations, which are often prejudicial to the patient. The glass shade for cut flowers is, on this account, peculiarly adapted to the sick-chamber, and is further especially serviceable in preserving them at seasons when they are expensive articles of luxury. I am happy to be able to state, that at the suggestion of my friend Mr. Burch, the Resident Medical Officer of the London Hospital, a sum of money has been collected by some ladies for the construction

of cases to be placed in the wards of the hospital; and one of these, very tasteful in design, I am enabled to exhibit this evening. I feel assured that their presence will be both gladdening and beneficial to the patients.

In the moral treatment of lunatics, and particularly in the æsthetic arrangements of large lunatic asylums, much yet remains to be done. "Take the long gallery at St. Luke's," observes Mr. Ward, "the gloomy tone of which is enough to depress the mind of a sane person, and introduce a dozen or two of closed cases into the walls, containing tableaux vivans of old ruins or natural scenery, covered with fresh and appropriate vegetation, and you would have one of the most beautiful promenades conceivable." Some years back Dr. Heath wrote to consult Mr. Ward respecting a lunatic gentleman who was under his care, and who was subject to attacks of mania which no ordinary means could in any way control. Prior to the onset of the malady, he had been conversant with, and very fond of botany, and the question now was, whether his attention might not be diverted, and his mind soothed, by a closed case of plants. The suggestion seemed a happy one; and a case, full of choice ferns and other plants, was immediately fitted up. The happiest results followed. On the occurrence of a severe paroxysm his attention was directed to the case, and the appearance of the plants produced an immediate alleviation of the violent symptoms; so that, while under Dr. Heath, no further difficulty was experienced. Unfortunately, however, after a time, he was transferred to the superintendence of another medical man, who was not so alive to the influence of æsthetic agents, and under whose care he relapsed into a worse condition than ever.

One of the earliest applications of these cases which suggested itself to the inventor, was for the transport of plants from one country to another. Under the old system, plants were either packed in boxes, or allowed to grow during the passage exposed to various noxious influences; and the consequence was, that an enormous

per centage died in transit. Now, it became evident that the same arrangement which effected isolation from prejudicial influences in large towns, would be available in protecting the plants through long voyages from the salt spray and rough winds, from the extremes of heat or cold, and in admitting the light and preserving the water which on shipboard is at times a precious commodity. Accordingly, in 1833, two cases were constructed, much stouter in the frame-work than those intended for rooms, and with the glazed top protected by wire-work. These were filled with ferns, grasses, and a few flowering plants, and entrusted to an intelligent friend, Captain Mallard, who was deeply interested in their success, and who engaged to take them under his charge to Sydney. They were lashed on to the poop of the vessel in a situation where they were exposed to the requisite amount of light, the plants were once sprinkled with water in a voyage of more than four months, and landed at Sydney in a perfectly flourishing condition. Within one case, on its arrival, was a primrose in full bloom, and the sensation occasioned by its appearance was so great, that it was necessary to keep the case under constant strict surveillance. Captain King, in the narrative of his voyages, relates that while he and some of his fellow-travellers were at dinner in a miserable hut on the banks of the river Awatska, the guests of a people of whom little was then known, and at the extremity of the habitable globe, a solitary half-worn pewter spoon, whose shape was familiar, attracted their attention, and on examination they found it stamped on the back with the word London. It would be impossible, he states, to understand the many pleasant thoughts, anxious hopes, and tender remembrances it excited in them. If a pewter spoon could produce such magic effect upon a party of wanderers, how must a primrose in full bloom have recalled to the colonists of South Australia the associations of their childhood, and reminded them of the woods and green lanes of their native land.

The case was brought back by Captain Mallard, filled with Australian treasures, some of which were for the first time seen alive in this country, to the great delight of the inventor and of the late Mr. G. Loddiges, who entered keenly into the importance of the plan, as he did indeed into everything of scientific interest. From this time the reputation of these cases for the transport of plants to and from different countries was established, and they became generally adopted for the purpose. The instances of failure resulted from captains and others, to whom they were entrusted, imagining that the cases possessed in themselves some talismanic action, by which the plants were preserved under any circumstances. In three or four large cases that Mr. Loddiges received on one occasion, the packer had painted the glass over, then covered it by way of protection with broad battens of wood, and lastly nailed a thick piece of tarpaulin over the whole. In consequence of this arrangement not a ray of light could reach the plants, which were all destroyed. In another case, from one of the West Indian islands, the plants had been roughly pulled up by their roots, and thrown in, without being planted properly in the soil, or any care taken as to the relative direction of roots and branches. Such failures as these, however, only served to illustrate the principle, not defeat the ultimate success of its application. One or two facts will suffice to prove the great benefit which the plan has conferred upon mankind in the conveyance of useful plants to and from different countries. By means of it, the late Mr. John Williams, missionary, was enabled to establish the banana, so important a food-plant to man, in one of the Navigator Islands, where it was previously unknown. Mr. Fortune conveyed nearly twenty thousand tea-plants, in Wardian cases, in safety and full health from Shanghae to the Himalayas. For most of the rare and beautiful palms that now adorn our large conservatories, we are indebted to this plan of conveyance. Even the seeds of palms cannot be brought to Europe

if packed in the ordinary way ; for, in consequence of their containing much oily matter, they soon become rancid, and decompose. They are now, accordingly, planted in the cases on leaving, germinate during the voyage, and, on arrival, the young palms are found to have sprung up. Sir W. Hooker bears ample testimony to the success of the plan, and states that, in the space of three or four years, nearly 3,000 plants have been sent in these cases to our different colonial possessions.

I shall sum up this part of my lecture by a quotation from a very philosophical paper by Mr. Daniel Ellis, which appeared some years ago in the "Gardener's Magazine:"—The celebrated Franklin, who looked at everything with the eye of a philosopher, and sought to turn to some useful purpose every observation which he made, in recording the reviviscence of some common flies which had made a voyage from Virginia to England in a bottle of Madeira wine, goes on to state, that a plant with its flowers fades and dies if exposed to the air without having its roots plunged in a humid soil, from which it may draw moisture to supply the waste of that which it exhales, and which is continually carried off by the air. Perhaps, he adds, if it were buried in quicksilver, it might preserve for a considerable time its vegetable life ; and, if this be the case, it might prove a commodious method of transporting from distant countries those delicate plants which are unable to sustain the inclemency of the weather at sea.

"The ingenious suggestion of the American philosopher has been happily realized in practice by Mr. Ward, in a way much more simple and efficient than that which Franklin proposed. By its means the rarest and most delicate plants have been transported to and from the most distant countries, with little or no trouble in regard to attendance, and scarcely any risk of suffering from the inclemency of the weather at sea. He has thereby conferred on the botanist and horticulturist benefits which no researches of travellers, however successful, nor expenditure of money, however

great, could have enabled them otherwise to procure. Instead of simple descriptions, or dried specimens, or fine pictures of foreign plants, they can now fix their eyes on living specimens, retaining their native freshness and beauty, and possessing all their natural and characteristic properties. Already have exchanges of plants between distant countries been carried on to a great extent, and the public conservatories, as well as those of private individuals, been enriched with specimens of many rare plants, which could scarcely have reached them by any other means. Thus, under the modified conditions with regard to climate, and the renovating processes in relation to water and air, which we have attempted to illustrate, the botanist and horticulturist may be said to have entered on new and unexplored fields of vegetable research, and to have acquired the means of transporting to their own soil the varied and most delicate plants of every region of the earth."

Among the philosophical appliances of these cases, may be noticed the opportunity they afford of studying many plants in an undisturbed atmosphere, in reference to their growth and habits, and the influence upon them of different stimuli, moulds, &c. In this respect, the inventor has turned them to good account, and more particularly in demonstrating the all-important influence of the vital stimulus, light, and thus inferring its agency upon man. This specimen of *Linaria Cymballaria*, one branch of which grew in a dark, the other in a very light part of his fern house, afforded him a text on which to enlarge, when called upon to give evidence on the subject before a Committee of the House of Commons, and induced him to exert himself with others to effect the removal of the window tax.

I come now to the last, but not the least interesting and important application of these cases—I mean to animals and man; (1) and here I must notice one or two points in the chemistry of animal and vegetable

life. Animals impair the atmospheric air by taking from it oxygen, and exhaling into it carbonic acid gas. Plants are also supposed, by certain physiologists, in their respiration, to deteriorate the air by throwing out carbonic acid. But in another process, analogous to the digestion of animals, and which is carried on, under the influence of the sun's rays, with the greatest vigour, they remove carbonic acid gas from the air, fix the carbon, give out the oxygen, and thus maintain the purity of the atmosphere; counterbalancing not only the influence of their own, but also that of the respiration of animals and man. This is not a mere picturesque theory, but a fact that has been proved experimentally by many philosophers. Lavoisier, in the latter part of the last century, took the first step in proving what has been happily termed "Nature's balance," by demonstrating the results of animal respiration. Senebier and De Saussure, in 1780, proved that plants in their respiration exerted the same influence upon air as animals, though the latter had clearly proved that their tendency, on the whole, was to purify the air. Dr. Priestley was the first to believe, from certain experiments, that plants instead of vitiating the air by their vegetation, reverse the effects produced in it by combustion and animal respiration, and thus maintain the purity of the atmosphere. By inserting plants in an air that had been previously vitiated by combustion and respiration, he found that the air was again restored to a condition capable of supporting those processes. One of his experiments was, first to place a candle in a closed bottle, and when it had gone out from want of fresh air, to plant therein a sprig of growing mint, which after a time was found to have restored the air to its original purity. On the occasion of presenting Dr. Priestley with the Copley Medal of the Royal Society in 1773, Sir John Pringle, the president, thus clearly expresses himself in reference to the balance of animal and vegetable respirations. "From these discoveries we are assured that no

vegetable grows in vain; but that from the oak of the forest to the grass of the field, every individual plant is serviceable to mankind; if not always directly by some private virtue, yet making a part of the whole which purifies and cleanses our atmosphere. In this the friendly rose and deadly nightshade co-operate; nor is the herbage, nor the woods, that flourish in the most remote and inaccessible regions unprofitable to us, nor we to them, considering how constantly the winds convey to them our vitiated air for our relief, and for their nourishment."(2) To Senebier is due, however, the credit of having shewn the precise influence exerted by vegetables in decomposing the carbonic acid given out in the processes of respiration and combustion; and he did more than this, for he proved that they exerted this action under water as well as in air. Other philosophers followed in his steps; and to shew that the fact was fully recognized at least thirty years back, I may cite the following remark from one of the first editions of Brande's "Elements of Chemistry." "Fishes," he says, "breathe the air which is dissolved by water; they, therefore, soon deprive it of its oxygen, the place of which is supplied by carbonic acid; this is in many cases decomposed by aquatic vegetables, which restore oxygen and absorb the carbon; hence the advantage of cultivating growing vegetables in artificial fish-ponds." (3) In Batavia, where some pools of water without vegetation rapidly became unfitted for use or for the purposes of animal life, it was found that by planting in them the *Pistia stratiotes*, the water therein was always kept in a state of purity. Boussingault discovered, further, that even the water itself was decomposed by vegetables, the hydrogen becoming fixed in them and the oxygen given out. Now, these marvellous counterbalancing actions of animal and vegetable life that are ever going on in Nature, both in the air and the water, we have it in our power to realize on a small scale in one of these cases; and Mr. Ward felt, many years ago, that the comparative isolation afforded

by his close glass covering would enable him to imitate these admirable harmonious processes. In 1841, he established in his largest fern-house, in a capacious earthern vessel given to him by Mr. Alfred White, an aquarium for fish and plants. In this vessel, which contained twenty gallons of water, and which he surrounded with rock-work raised several feet above its margin, he placed ten or twelve gold and silver fish, in company with several aquatic plants, viz., *Valisneria spiralis*, *Pontederia crassipes*, *Pistia stratiotes*, and *Papyrus elegans;* a species of *Adiantum*, and other lovely ferns, planted in the surmounting rock-work, throwing a graceful shade over the surface. In this miniature lake, the water of which was never changed, but maintained in a constantly pure state by the action of the associated plants, the animals lived in a flourishing state for years. This aquarium soon gave the hint to another naturalist, Mr. Bowerbank, who established a large glass jar covered with a lid, and containing *Valisneria spiralis* in company with some sticklebacks and minnows. To use that gentleman's own words: "They did exceedingly well together; were seen and admired by numerous parties who frequented my Monday evening meetings. I believe my jar was the second experiment that arose out of your suggestions on that subject."

Mr. Mitchell, Secretary of the Zoological Society, who has exhibited a most comprehensive spirit in his endeavours to realize the natural conditions of different animals, states that the transparent jar of Mr. Bowerbank gave him the hint which resulted in the establishment of the interesting vivaria at the Gardens. Fresh-water aquaria containing associated plants and animals are of much older date than is generally supposed, and were, in fact, ornaments of the philosopher's study nearly a hundred years ago. In a work on "Microscopical Recreations," by a German named Ledermüller, are two coloured prints; the one, of a bottle containing hydras and other animalcules,

with duck-weed; the other, of one containing fresh-water zoophytes, with duck-weed on the surface of the water, and Chara and some other plant inserted in sand at the bottom. Professor Quekett, to whom I am indebted for reference to the work just noticed, has had, for some years, at the College of Surgeons, a glass globe containing hydras and valisneria. Towards the close of 1846, Mrs. Thynne established, for the first time in London, two small marine vivaria, having been led to do so by her desire to bring some madrepores in a living state up from Torquay to London. (4) For a few months this lady kept the water in these vivaria daily aerated by letting it fall from a height into the tanks, and occasionally sent to the coast for fresh sea-water, and thoroughly renewed it; after a time, however, she tried to adjust the balance between animal and vegetable life by inserting shells and pieces of rock with living sea-weeds attached, and subsequently depended upon these for the purification of the water.* Those who visited the vivaria at the Zoological Gardens during the winter, must have remarked that the fresh-water plants in the tanks were thickly covered with confervæ. I was assured, when I saw them so covered, and expressed my regret that their beauty was so much impaired thereby, that a sufficient number of fresh-water snails would have removed the whole in a few days, but that they were not then easily to be procured. Who the ingenious naturalist was who first suggested the introduction of these little animals to do the work in question, I am not clearly informed; but, in a number of the "Microscopical Journal," for Sept. 2, 1841, I find the following memorandum: "It is very generally known to those observers who keep valisneria for microscopic purposes, that in the course of a short time the whole plant becomes covered with a very delicate conferva, or some nearly allied genus; to remove which, it has been recommended to place a few fresh-water snails, such as the species of Limnæus, *Planorbis*, *Phy-*

* *See* her statement, which is appended.

sa, &c., to be met with in plenty in almost every stagnant pool or ditch." (5) Some years before this notice appeared, Mr. Cornelius Varley had, I am informed, used them for the purpose in question. Mr. Ward, I may state, has only so far taken credit to himself as having introduced vivaria into his closely glazed cases, and depended for their success on the counterbalancing actions of animal and vegetable life.

In the same closed case with the vivarium were a robin, a chameleon, and a Jersey toad. The last lived there for ten or eleven years, and became a sort of pet.

By considerably increasing the volume of air in these cases, and introducing plants of larger growth and high purifying action, there can be little doubt that they may be successfully applied to the higher animals, and even to man. Medical men have long felt the want of sanatoria, in which they might realize a sort of artificial Madeira, or any other climate. In the early part of this century, Dr. Beddoes, and one or two other physicians, paid particular attention to the maintenance of equable temperature in the rooms of their consumptive patients, and but imperfectly carried out their designs by means of German stoves, and what was then known of the principles of ventilation. Dr. Arnott, in his "Elements of Physics," published more than twenty years ago, describes a contrivance for the same purpose. But this and other plans had reference only to peculiar arrangements of ordinary sitting-rooms. It was left to Mr. Ward to suggest a more philosophical mode of realizing artificial climates in a peculiarly constructed and arranged chamber or building, to which the term *sanatorium* has since been applied. His views upon the subject were first brought before the public in the lecture delivered by Professor Faraday in 1838, and are clearly expressed in the first edition of his work, "The Growth of Plants, &c.," published in 1842. Those who are acquainted with the means by which M. Payerne and his crew contrived to

remain for twenty-four hours in a submarine vessel under the Seine, will admit that, whatever may be the difficulties in the way of erecting such a building, they are not insuperable. (6) Sir J. Paxton's proposed sanatorium in connection with the Hospital for Consumption at Victoria Park, is the first attempt to realize a building upon the principle laid down by Mr. Ward.

I have thus, I trust, fulfilled the purpose with which I presented myself before you this evening. I have demonstrated the success of Mr. Ward's plan in the growth of plants in crowded towns, and their transport from one country to another; and I have also vindicated his right to the suggestion of their application to animals and man. Those who have installed one of these cases among their "household gods;" who have been wont to rejoice in the graceful forms and refreshing tints of its occupants; who have, from day to day, watched with keen interest their quiet phases of development, and felt their cheering influence amid the cares and troubles of life, will, perhaps, admit with me—and who that regards a luxuriant plant of *Trichomanes speciosum* in its little isolated world can help admitting it?—that no inappropriate motto for the Wardian case is to be found in the line with which Keats opens his 'Endymion,'

"A thing of beauty is a joy for ever!"

APPENDIX.

Note (1), p. 18.

Conclusion of Mr. Ward's "Report on the Growth of Plants," &c., to the British Association, held at Liverpool, 1838.

"I think it is quite needless to point out the various important applications of the above facts to the growth of plants in towns, their conveyance and growth on ship board, or the numerous physiological inquiries which may now be made with much greater facility and certainty than heretofore; but, *I wish to direct the attention of the Members of the British Association to the development of animal life upon the same principles. I am quite certain that a great number of animals would live and thrive under this treatment; and I can see no reason why, at the same time that our stoves are ornamented with Rafflesias, they may not be illuminated with Fulgoras and Candelarias.*"—Ass. Rep. p. 505.

"At the Meeting of the British Association at Oxford, in 1847, Mr. Ward called attention to the fact, that all the lower marine algæ might be grown in these cases by means of salt-water artificially prepared."—*Athenæum*, July 3rd, 1847.

Note (2), p. 20.

Sir John Pringle concludes this portion of his discourse as follows:—"And if ever these salutary gales rise to storms and hurricanes, let us still trace and reverence the ways of a beneficent Being, who, not fortuitously, but with design—not in wrath, but in mercy, thus shakes the waters and the air together, to bury in the deep those putrid and pestilential effluvias which the vegetables, on the face of the earth, had been insufficient to consume."

Note (3), p. 20.

In the sixth edition of Brande's "Manual of Chemistry," published in 1848, it is stated, that "About 1778, Dr. Priestley made the capital

discovery of the evolution of oxygen by aquatic plants, growing in water containing carbonic acid: that the presence of light was necessary to this change: that in sunshine it was most rapid: that it was in a great measure independent of warmth; and, lastly, that the bladders of some kinds of sea-weed contained air purer than the atmosphere. The renovation of the air contained in water requisite for the respiration of fishes was thus accounted for, and the circumstance of fishes and most other aquatic animals being unable to live for any time in pure water, accounted for."

NOTE (4), p. 22.

"In the Autumn of 1846, when touring through Devonshire, I first met with the living madrepore. Having for many years derived much pleasure from the study of geology, I felt great interest in seeing a *living* species of little creatures so intimately connected with that science. I procured about thirty of them, to watch and admire during a few weeks residence at Torquay, and felt so much desire to shew them to a friend in London, that I determined to try whether they would not survive the journey, though it was rendered more difficult by our intention of passing three weeks at Clifton on our way to town. I provided myself with a stone-jar and six gallons of pure sea-water, taken from a deep part of the channel; with a needle and thread I fixed the madrepores on a large sponge, that there might be no damage from collision, and then placed them in a glass-jar, filled to the brim with water, and tied down with a bladder. This method was perfectly successful. During the journey I had the great pleasure of seeing them expand their tentacula most happily; and they arrived both at Clifton and London in a most flourishing state. My next consideration was on the possibility of keeping them alive, and this I accomplished in the following manner. I placed them in two glass bowls, holding about three pints of water each, which I changed every other day; and as I could not have a continual supply sufficient for such a demand, I thought of having it aërated by pouring it backwards and forwards before an open window for half- or three-quarters of an hour between each time of using it. This was, doubtless, a fatiguing operation; but I had a little handmaid, who, besides being anxious to oblige me, *thought it rather an amusement;* so that as the service was cheerfully performed it was also done well, and the exertion was diminished by her standing for only ten minutes, or a quarter-of-an-hour, at one time. At the expiration of three months, although I could discover no deterioration in the water, I thought it safe to send my stone-jar to be refilled; and this I continued to do every

three months, so long as I kept a collection in London. For six or seven months the little madrepores had no other food than the water supplied; but as they then looked rather thin, I fed them with boiled shrimps, cut very fine, which soon restored them to their usual beauty.

"In the Spring of 1847, I wished to try whether I could adjust the balance between animal and vegetable life, and sent for shells and small pieces of rock, to which living sea-weed was attached. On these shells, &c., were sure to be many zoophytes and other animals, so that I obtained a very various and curious collection of marine creatures. I had a quantity of microscopic corrallines, which multiplied very fast; serpulæ, that rapidly elongated their stony cases; some nereis, ophiuræ, and a great many beautiful little things for which I could find no name. On one piece of rock was the first germ of a living sponge. I watched the shooting forth of its spicula with the greatest interest. It was very fine, and grew to the size of a hazel nut, coming to maturity in about six weeks. In the course of the next winter, from want of motion in the water, it had become so covered with dust, that I did not know whether it were alive or dead; but in the following June a bright spot appeared on one side, and it threw forth a sporule which attached itself to the rock, and in about six weeks a full-grown young sponge stood beside its parent. I placed this sponge in a darkened room, and found the spicula grew most on whichever side was turned to the light. From this time I regularly placed sea-weed in my glass bowls; but as I was afraid that I might not keep the exact balance required, I still had the water refreshed by aëration. I do not know from which, or whether it was from both causes, that my little flock continued to thrive so much, but I seldom had a death. Perhaps such creatures have great tenacity of life. A nereis propagated by germination, and the caryophyllia, regularly threw out their ova at the usual season. These ova lay quietly upon whatever they were thrown for one or two days, when they began to rotate, and first slowly and then more quickly; but I could not secure them, as they were so fine that they passed through, or adhered to anything through which I strained the water; in the mass, to the naked eye, they looked like fine dust. A week or two after one of these ejectments of ova, I discovered with my glass what I at first thought were minute ova, though on touching them I found they were really the pearl-like tips of two young madrepores; but as the piece of rock on which they were fixed had not been in my possession many weeks, I could not decide whether they were born in the ocean, or came from ova which might have adhered. However, as they grew in years, they so *exactly* resembled one of the older ones, both in the *precise shade of colour* and the *centre star*, that I felt convinced they

were truly town-breed. The madrepores vary so much in their *shade* of colour, that (excepting the pure white ones), I never procured two full grown ones *exactly* alike both in the centre and the outward part. In this manner I maintained my collection in London for nearly three years, after which time we went to reside by the sea-side for nine months in the year. I then took them with me, and pursued my researches in the Marine Kingdom under ordinary circumstances. —Anne Thynne."

"Was there any need of adding any additional proof of the vegetability of the Corallines, an experiment now in progress before me would seem to supply it. It is now eight weeks ago since I placed in a small glass-jar containing about six ounces of pure sea-water, a tuft of the living Corallina officinalis, to which were attached two or three minute *confervæ*, and the very young frond of a green Ulva; while numerous Rissœ, several little mussels and annelides, and a star-fish, were crawling amid the branches. The jar was placed on a table, and was seldom disturbed, though occasionally looked at; and at the end of four weeks the water was found to be still pure; the mollusca and other animals all alive and active; the *confervæ* had grown perceptibly, and the coralline itself had thrown out some new shoots, and several additional articulations. Eight weeks have now elapsed since the experiment was begun—the water has remained unchanged, yet the coralline is growing, and apparently has lost none of its vitality, but the animals have sensibly decreased in numbers, though many of them continue to be active, and shew no dislike to their situation. What can be more conclusive? I need not say, that if any animal, or even a sponge, had been so confined, the water would long before this time have been deprived of its oxygen, would have become corrupt and ammoniacal, and poisonous to the life of every living thing."—Dr. Johnston's *History of British Sponges and Lithophytes.*

Note (5), p. 23.

"Tho food of the Limnei is animal and vegetable matter in different states of putridity, which makes them deserve the perhaps not inapt epithet of 'Scavengers of the Waters.'"—Jeffrey's in *Linn. Trans.*, vol. xvi., p. 2, 1830.

Note (6), p. 24.

It is worthy of note that the means employed by Payerne, viz., the evolution of oxygen by means of a salt dissolved in water, should hav

been hinted at by the great Boyle, who, observing, as he himself informs us, how much air was concerned in many of the phenomena of Nature, and how necessary it was to the existence of animals, became solicitous to inquire whether a fluid of so much importance were not producible by art; if so, he believes that such air might be serviceable in life, particularly in the art of diving, and in submarine navigation.

Since the delivery of the foregoing Lecture, I paid a visit to the residence of J. G. Appold, Esq., F.R.S., and was much struck with his arrangements for ventilation, the regulation of the quantity of air according to circumstances, and its effective sifting prior to its introduction into the several apartments.

T. E. Metcalf, Printer, 63, Snow Hill, London.